

Bakken Crude Oil & Response Considerations



EPA Region 10
Emergency Management Program
Fall 2013 OSC Training



Basics of Crude Oil – Quick Review

- Crude Oil - very complex mixture of hundreds, even thousands of chemical compounds
- Chemical composition can vary tremendously
 - From different producing regions
 - Possible even within a particular formation

Basics of Crude Oil – Quick Review

- Hydrocarbons are most abundant compounds in crude oil
 - Carbon (80 – 87%)
 - Hydrogen (10 - 15%)
- Non-hydrocarbon compounds, typically <10%
 - Sulfur (0 -10%)
 - Nitrogen (0 – 1%)
 - Oxygen (0 - 5%)
 - Trace Metals
 - V, Ni, Fe, Al, Na, Ca, Cu, U

Basics of Crude Oil – Quick Review

Non-hydrocarbon Constituents

- Sulfur Compounds
 - Very important non-hydrocarbon compounds
 - Hydrogen sulfide, mercaptans, sulfonic acids
- Nitrogen Compounds
 - Present in all crude oils
 - Pyridines, quinolines, pyrroles, etc.
- Oxygen compounds (found in distillation fractions)
 - Organic acids, Alcohols, ketones, esters, phenols

Basics of Crude Oil – Quick Review

Terminology

- Light Crudes - have more “light ends”, such as gasoline, naphtha, and kerosine fractions
- Heavy Crudes have more heavy ends such as asphaltenes (higher molecular weight)
- Sweet, Sour Crudes: refer to amount of sulfur present
 - Sweet < 0.5% sulfur
 - Sour >0.5 % sulfur, Safety Issues
 - **H₂S danger, air monitoring needs**

Basics of Crude Oil

Terminology

- API Gravity – a specific scale, created by API, for measuring the relative density of petroleum liquids, expressed in degrees.
 - $\text{API Gravity} = (141.5/\text{Sp.Gr at } 60^\circ \text{ F}) - 131.5$
- Rule of Thumb
 - Higher API Gravity = lighter the crude, less viscous, more light ends
 - Heavy Crudes ~ API 18°
 - Light Crudes ~ API 38° - 44 °

Group 2 Oils: Diesel-like Products and Light Crude Oils

- No. 2 fuel oil
- Diesel fuel
- Home heating oil
- Jet fuels
- Kerosene
- West Texas crude
- Bakken crude



Group 2 Oil: Diesel-like Products and Light Crude Oils

- Moderately volatile
- Refined products can evaporate – little to no residue
- Crude oils do have considerable remaining oil and residue after evaporation
- Low to moderate viscosity; spreads rapidly into thin slicks
- Specific gravity is 0.80-0.85; API 35-45

Group 2 Oils: Diesel-like Products and Light Crude Oils

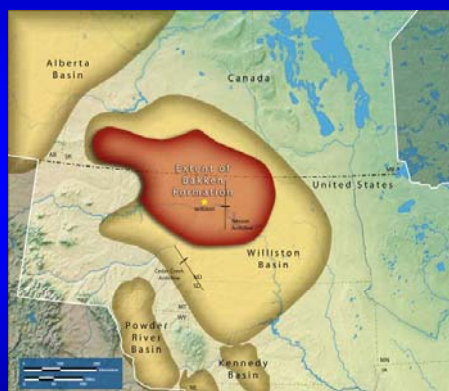
- Crude oils can form stable emulsions
 - Weathered/mousse
- Tend to penetrate substrates; fresh spills are adhesive
- Moderate to high acute toxicity to biota; product-specific toxicity is related to type and amount of aromatic hydrocarbons

Bakken Formation Crude Oil



Bakken Crude Oil

- Bakken Formation underlies over 200,000 square miles in Williston Basin of MT, ND, Saskatchewan
- Recoverable reserves up to 24 Billion bbl



Properties & Response Considerations

- Properties
- Spill Response

Cenovus MSDS

cenovus LIGHT CRUDE OIL		
1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION		
Product Identifier:	LIGHT CRUDE OIL	
Synonyms:	Bakken Oil, Bakken Crude	
Chemical Description:	A naturally occurring mixture of aromatic hydrocarbons and small amounts of sulfur and nitrogen compounds	
Product Use:	Process stream, fuels and lubricants production	
Manufacturer/Supplier:	CENOVUS ENERGY INC. 500 Centre Street SE, PO Box 766 Calgary, AB T2P 0M5	
Prepared By:	Cenovus Energy Inc. Health and Safety	
Phone Number:	1-403-766-2000	
Emergency Telephone:	1-877-458-8080, CANUTEC 1-813-996-6666 (Canada)	
2. COMPOSITION/INFORMATION ON INGREDIENTS		
Hazardous Ingredients	CAS Number	Approximate Concentration (%)
Petroleum Crude Oil	8002-05-9	100 w/v
Benzene	71-43-2	0.1 - 1.0 w/v
Hydrogen Sulfide in liquid is <0.1% w/v, vapour phase may contain higher concentrations.		
3. HAZARDS IDENTIFICATION		
Routes of Entry:	Skin contact, skin absorption, eye contact, inhalation, ingestion	
Emergency Overview:	Warning: Flammable liquid and vapour. Liquid and vapour may cause irritation or burns to eyes, nose and throat. Inhalation of vapour may cause dizziness and discomfort. Possible cancer hazard (benzene). Possible asphyxiation hazard (hydrogen sulfide). Wear personal protective equipment appropriate for the task.	
<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;"> WHMS 82, 02-A, 02-B WFA 14, 10, 10 </div> <div style="text-align: center;"> </div> </div>		
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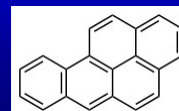
Bakken Crude Oil Properties

- Light crude – Class 2 Oil
 - same class as Diesel #1 Fuel Oil
- API gravity ranging from 40° to 42°
- Sulfur content ranges from 0.17- 0.20%
 - Bakken is a “Sweet” crude
 - Reports of some sour recent shipments due to crude blending
- Benzene content < 0.5% by weight



Bakken Crude Oil Properties

- Sp. gr. of Bakken is 0.7 – 0.8, Floats on water
 - Sp. gr. - weight of oil/ weight of “pure” water
 - 10 °API = 1.00 s.g. or pure water at 60°F
- Vapor Density 1.5 – 3.0, heavier than air
 - Vapors can hug ground and travel to an ignition source
- Vapor Pressure moderate, mmHg 280 – 360 @ 60° F
 - Water 12.5 mmHg @ 60° F
 - Gasoline 400 mmHg @ 60° F



Bakken Crude Oil Properties

- Flammable (Class 3)
- Sensitive to static discharge
- Explosive Limits variable:
 - LEL 0.4%
 - UEL 8 - 15%
- Flash point - 40° to 100° C
- Stable
- Incompatible with strong oxidizing agents



Properties & Response Considerations

- Properties
- Spill Response
- Safety

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Spill Response Considerations

▪ Behavior in River

- Floats
- Middle of fast river
- When slowing, will go to bank in curve
- Stranding on shorelines
- Entrainment
- Binding with sediment
- Dissolution
- Weathering, mousse development



Spill Response Considerations



BMG Spill



BMG Spill Site

BMG Spill



Water & oil flow under ice



BMG Spill



Frozen pond of ice over oil



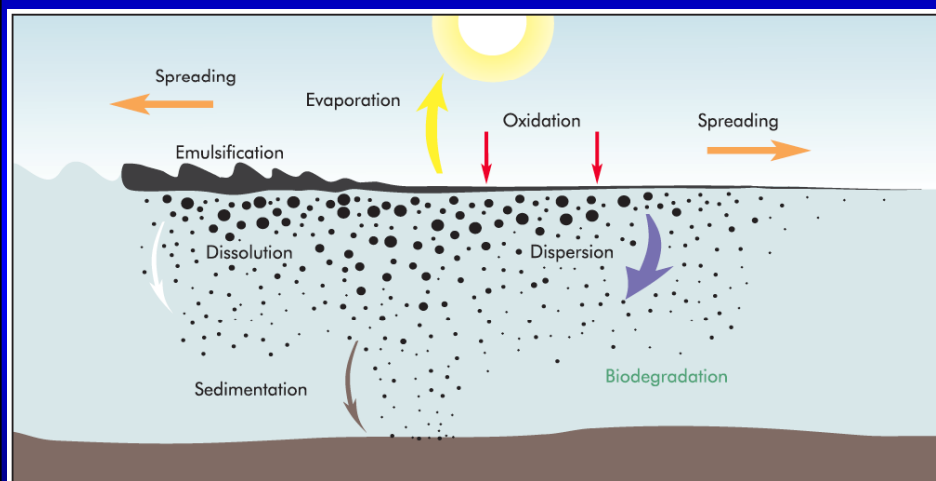
BMG Spill

Thawing,
heavily oiled
arroyo and
grasses



Spill Response Considerations

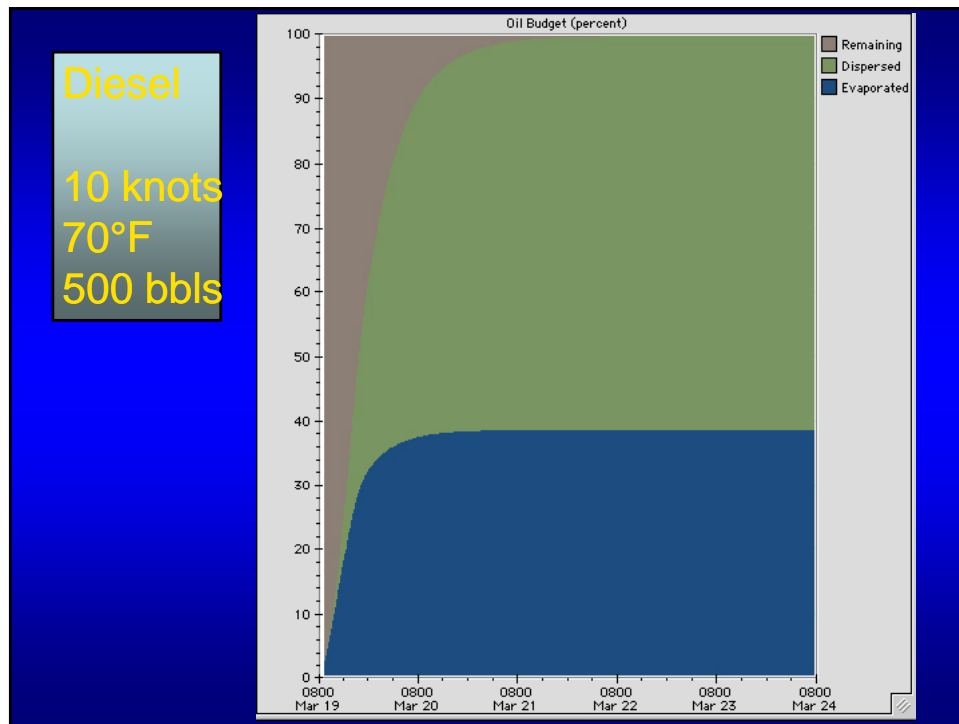
dynamics in water



Response Considerations

Evaporation

- Key factor for light crudes, including Bakken
- Can be the most significant “loss” mechanism early in a spill
- Small impact on density
- Significant impact on viscosity
- Function of: oil type, environmental factors
 - Crude oil - up to 25% loss in 24 hours
 - Gasoline - up to 50% loss in 10 minutes
 - No. 6 fuel oil – 5-10% loss in 40 hours



Oil Spill Response Techniques

- Physical Measures to be deployed –Stop it, Boom it, Suck it up
 - Boom it (mechanical and sorbent boom)
 - Put in underflow and weir dams
 - Flushing, soil washing (water, leaf blowers, etc.)
 - Sorbent material (pads, pompoms, etc.)
 - Suck it up – Vacuum Trucks
 - Dispose of it correctly
 - Soil and vegetation excavation, bioremediation

Spill Response Considerations



Spill Response Considerations



Underflow Dam

Spill Response Considerations



Spill Response Considerations

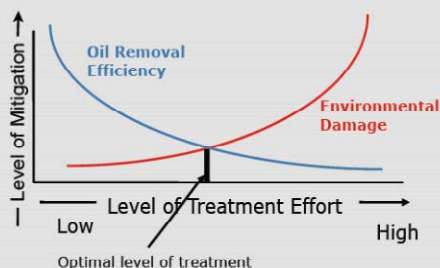


Spill Response Considerations

SCAT – NEBA limits

The NEBA process also involves knowing what to do (**response options**), what not to do (**response constraints**), defining when the job is done (**end points**), and determining when the job is done (**sign-off**).

The Recovery Rule
"The more effort to remove oil, the greater the degree of environmental intrusion"



EnviroEmerg - Module 3: Net Environmental Benefit 9

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- Properties
- Spill Response
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Spill Response Considerations Safety

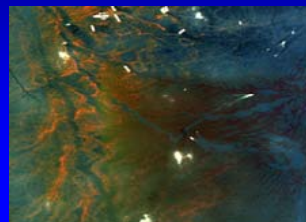
- PPE
 - Level D most often, but be prepared for upgrade
- Air monitoring
 - Explosive Levels
 - H₂S
 - Benzene
 - Organic vapors
 - Petroleum Hydrocarbons
- Equipment considerations

Exposure Guidelines

Component	ACGIH	NIOSH	OSHA
Petroleum (8002-05-9)	Not established	CEIL: 1800 mg/m ³ TWA: 350 mg/m ³	Not established
Hydrogen sulfide (7783-06-4)	TWA: 1 ppm STEL: 5 ppm	CEIL: 10 ppm	CEIL: 20 ppm
Benzene (71-43-2)	TWA: 0.5 ppm STEL: 2.5 ppm	TWA: 0.1 ppm STEL: 1 ppm	TWA: 1 ppm STEL: 5 ppm
Ethylbenzene (100-41-4)	TWA: 20 ppm	TWA: 100 ppm STEL: 125 ppm	TWA: 100 ppm
Toluene (108-88-3)	TWA: 20 ppm	TWA: 100 ppm STEL: 150 ppm	TWA: 200 ppm CEIL: 500 ppm

Cleanup Endpoints

- Cleanup endpoints can be:
 - Qualitative which are based primarily on visual, olfactory, or tactile observations and do not necessarily require collection of analytical chemistry data
 - Quantitative which rely on measurements or quantitative data, as opposed to qualitative data such as categorical observations (e.g., sheen or no sheen)



Examples of Qualitative Cleanup Endpoints

- There is no longer any detectable constituent or compound of concern present on the water, adjoining shorelines, or places where it is likely to reach the water again
- Further removal operations would cause more environmental harm than the constituent or compound of concern to be removed
- Cleanup measures would be excessively costly in view of their insignificant contribution to minimizing a threat to the public health or welfare, or the environment



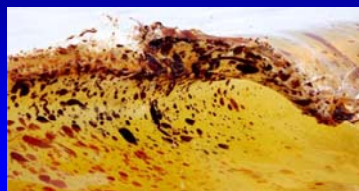
Examples of Quantitative Cleanup Endpoints

- Constituent or compound of concern on surface water, groundwater, soil, or sediment does not exceed background concentrations for the constituent or compound of concern
- Constituent or compound of concern on surface water, groundwater, soil, or sediment does not exceed predetermined concentrations for the constituent or compound of concern



Issues Affecting the Selection Of Endpoints

- Type and amount of constituent or compound spilled
- Type of shoreline
- Value of habitat or use of the segment and the timing of that use
- Technical and operational feasibility of cleanup activities
- Anticipated rate of natural attenuation
- Environmental influences such as weather
- Perceptions of risk



Practical Considerations for Achieving Cleanup

- Type and amount of constituent or compound spilled
- Environmental sensitivities
- Consultation
- Widely varying cleanup standards



Practical Considerations for Achieving Cleanup . . .

- Long-term deployment of absorbent materials
- Not all spilled constituent or compound oil will be recovered
- Weather
- Natural attenuation



Practical Considerations for Determining When the Cleanup is Complete When Not All Spilled Constituent or Product is Recoverable

- Technical and operational feasibility of investigation and cleanup
- Is there a balance between cost in relation to the added degree of protection or reduction of risk afforded by additional cleanup?
- Is there a state or other entity that has the capability to assume responsibility for the cleanup action?
- Anticipated rate of natural removal processes

